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BUREAU OF MINES
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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

TECHNIQUE FOR ROUTINE USE OF THE KONIMETER[1]

By J. B. Littlefield[2], C. E. Brown,[3]
and H. H. Schrenk[4]

The term "konimeter" is used generally to designate a type of dust-sampling instrument that collects the dust from a small volume of air by impingement on a glass plate prepared with an adhesive film. The konimeter was first developed by Sir R. N. Kotze about 20 years ago and was followed a few years later by the circular-type konimeter, by which a number of samples may be collected on a glass disk. The present discussion will be confined to the circular type, as it is used most.

Various techniques have been developed for using the konimeter, and many materials, such as petrolatum, mineral oil, and glycerine jelly, have been used in preparing the adhesive film. In South Africa, Australia, and Canada, where the konimeter has been employed most widely, dust samples are treated by ignition and washing before being counted. In Canada the dust samples are collected on a disk of special heat-resistant glass prepared with a film of mineral oil; the disk is then heated to a dull cherry-red in a muffle-furnace to remove the film and organic matter, cooled, and washed with a few drops of 50-percent hydrochloric acid followed by distilled water and alcohol, and then heated again to remove residue left by evaporation of the alcohol. After this treatment, the dust samples are counted under a magnification of 150 diameters with dark field illumination.

The Bureau of Mines uses the konimeter in addition to, rather than in place of, the impinger; it is most useful for preliminary work, for estimating the effectiveness of dust-control methods, and for determining the relative amounts of dust produced during various phases of a dust-producing operation; for such purposes ease and rapidity of sampling and estimation are particularly desirable. However, where more representative sampling is desired the impinger, which samples much larger volumes of air over longer periods, is used. Konimeter samples collected by the Bureau of Mines are counted directly, without any treatment, and with light field illumination.

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Some konimeter models are sold with a microscope attached and are useful for making rapid observations and rough estimates in the field. These combination models are useful for selecting sampling places and estimating the sampling period for other methods, which at present are in more general use for legal and similar purposes. A description of the technique used by the Bureau of Mines is presented for the benefit of others, particularly in the mining industry, who are using this apparatus for control or preliminary dust surveys, as it is much less cumbersome than the impinger.

DESCRIPTION OF KONIMETER

The konimeter consists of a small valveless pump with a spring-operated piston of the leather-cup type. A catch holds the piston in a depressed position against the compression of the spring. Releasing the catch allows the piston to move rapidly to a stop, which may be set for 2.5- or 5-cc samples. The cylinder opens into a space between the metal body of the instrument and the glass sample disk. A seal is maintained around the periphery of this space by a small rubber gasket, which also serves to space the glass disk from the intake orifice at the proper distance of 0.5 to 0.6 mm. This distance should be checked by the microscope, by a micrometer screw, or by a thin strip of metal.

The sample volumes for the 2.5- and 5-cc sampling positions may be checked by connecting the intake (after removing the screen and retaining ring) to a water-filled burette. A glass reducer connected to the instrument is connected to the top of the burette (a 5-cc microburette with two-way cock) by a short length of 5-mm rubber tubing. With the piston cocked in either position, the liquid is leveled at a mark by adjusting the leveling bulb and turning the cock to each position several times. Then with the cock connecting the konimeter to the burette open, the piston is released and at the same time the leveling bulb is raised to the approximate position. After leveling, the sample volume is read on the burette.

In the type of konimeter used by the Bureau, the glass sample disk is cemented in a metal rim and has 30 numbered sample positions spaced equally on a circle just inside the rubber gasket. A pawl stops the rotation of the disk at each sampling position. An orifice or nozzle in the body of the instrument faces the inside of the glass sample disk. The nozzle is round and about 0.5 to 0.6 mm in diameter. This size is readily checked with a microscope. The nozzle opens through a cone to the outside and is protected by a 250-mesh screen from being clogged by large particles. Some instruments are provided with a sintered glass filter, but this is not recommended, as some particles from one sample are held and released on the next one.

The pump should be lubricated with a grease (graphite may be used) that limits the motion of the plunger to a speed that gives an air velocity of 100 to 150 meters per second through the nozzle. In other words, the plunger should make the full or 5-cc stroke in about 1/4 second or the half stroke in 1/8 second. An experienced observer can tell from the spread of the particles on the disk whether the sampling rate is right. If it is too slow, the particles will extend beyond the field of view in the microscope; if too rapid, even low concentrations will be grouped so closely that counting will be difficult.

PREPARATION FOR USE

Cleaning Disk

In preparing the konimeter for use, first see that the plunger moves smoothly and that the screen and nozzle are clear. The disk may be cleaned by scrubbing with a camel-hair brush (or with the fingers), using a mild soap and distilled water. (Some of the liquid soap or liquid cleansing solutions on the market may be used with tap water for this purpose.) Rinse thoroughly, then dry and polish with a clean cloth of handkerchief linen, and brush in one direction with a clean camel-hair brush. If the humidity is low and dust and lint are held on the glass by static charges, breathing lightly from the mouth on the disk and brush will help.

Application of Adhesive

An adhesive film is applied to the sample side of the disk. A mixture of 1 ounce of microscopic glycerine jelly (Martindale) and 1 ounce of pure glycerine with 10 to 20 drops of distilled water (less in hot weather than in cold) is a satisfactory adhesive. The ingredients are heated in a clean bottle held in hot water (do not boil) until the jelly melts and mixes completely with the glycerine and water. After cooling a few hours, it sets to a soft jelly and is ready for use.

The index finger is used to apply the adhesive to the sample disk; wash the hands thoroughly in warm water, then hold the index finger and thumb in cold water (to close the pores), dry on a linen cloth, and brush to remove lint. A piece of the jelly about the size of a pinhead (about 1/16 inch in diameter) is held between the thumb and finger until it softens, and then is spread on the sample disk by the index finger, turning the disk to attain a sweeping circular motion. Particular care should be taken not to rub the jelly between the thumb and finger, as small bubbles that form in the jelly cannot be removed and may be confused with dust particles. The streaks left by the finger ridges may be removed by breathing gently from the mouth on the disk until the hygroscopic jelly has taken up enough moisture to spread. Sample disks should be prepared in an atmosphere as free from dust as possible. If the sampling side of the disk is held down while the adhesive is applied, atmospheric dust is less likely to be deposited on it.

The disk is then examined under the microscope, and if there are more than 8 to 10 particles per field it is cleaned and prepared again. A little practice makes this preparation simple and easy. The disk is placed on the konimeter with the adhesive side toward the orifice or, if to be used later, in a special metal carrying box, adhesive side down. (After preparation, the disks should always be handled with the adhesive side down.) The threaded rim is put on over the disk on the konimeter and turned until the rubber gasket makes good contact. The konimeter is now ready for collecting 30 samples, but numbers 10, 20, and 30 are best left as blanks.

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COLLECTION OF SAMPLES

The konimeter with the piston depressed and set at the 2.5- or 5-cc mark is held in one hand, with the glass disk up, at arm's length and with the operator facing the air current. The cover over the intake should be open, of course, while sampling is done and closed immediately after. After the operator has stood motionless a moment, the catch is released by pressing with one finger. The location, number, and volume of the sample and other pertinent data should be noted at once. The disk is turned at once to the next position and the piston is again cocked. In general, it is advisable to take three or more samples at each location and average them. The konimeter is of little value where dust is plainly visible, as any concentration above 50 to 60 million particles per cubic foot of air makes a spot that is too heavy to count and is labeled TMC (too many to count).

In virtually any active plant or mine the 2.5-cc sample will be large enough, although in intake air or fresh air out of doors the sample may have to be 5, 10, or even 25 cc to yield a reliable count. Where the approximate concentration can not be estimated, several samples 2.5- and 5-cc in volume may be collected.

In drilling operations oil and water mist may mask the true count; however, a thicker film of the glycerine-jelly mixture will absorb most of the water mist if allowed to stand overnight. Oil drops are readily recognizable and, except under unusual conditions, no great difficulty is experienced with them. Where mist is not encountered, a thin film of the adhesive will be found more satisfactory.

By exercising a little care and holding the adhesive-treated side down, filled sample disks may be changed for blank ones at any time. The raised ring in the special metal boxes forms an enclosed space about the samples and protects them.

COUNTING SAMPLES

A microscope with 10-magnification (16-mm) objective and a compensated 20-magnification eyepiece in which there is a squared micrometer and sector is used for counting the samples with light field illumination. Most of the sectors are 18°, although some of only 9° are made. If there is any doubt concerning the size of the sectors, they may be measured with a microscope having a revolving stage. The lines that mark off these sectors do not extend to the center; if they did, their thickness would obscure many particles at the most concentrated point. Therefore, in counting, the operator must project imaginary lines to the center.

Two types of stages are used; one has a ring similar to that on the konimeter for holding the sample disk and is provided with a pawl that stops the disk at each sample position. When one spot is located, each of the other may be turned into the field readily. This ring is adjustable in two horizon directions and in this way the spot is centered in the field, so the same numbers of dust particles appear outside each of the sides of the heavy square in the center of the micrometer.

The other type is a standard mechanical stage modified to hold the konimeter disk. With it somewhat more difficulty is encountered in finding and centering the samples.

Artificial illumination ordinarily is used in examining konimeter samples. The lamp is placed about 9 inches from the microscope mirror and stopped down by the lamp iris diaphragm to about 1/2 inch. The microscope substage mirror then should be adjusted to throw the beam of light into the eyepiece. The correct focus is found most easily by locating one of the lines on the sample disk that separate the sample positions. The coarse adjustment is racked up and down until the line appears widest; then the fine adjustment is turned until particles in the adhesive film are clearly visible. The first sample is then turned into position and centered in the field; a very small particle is brought into focus, and the iris diaphragm of the microscope substage is closed until the best visibility is obtained. All of the particles in the two sectors are counted, and for more accurate work the eyepiece can be turned so two more sectors at 90° can be counted. The sectors and micrometer squares may be focused clearly by turning the top lens in the eyepiece. An extra line outside each sector and spaced so the distance is 5 microns on the field of focus is provided for estimating large particles that are commonly omitted from the count if estimated to be above 10 microns. Dust particles estimated to be less than 10 microns in size are counted on sectors of each blank on the sampling disk. They are averaged for the number of blanks and deducted from the count for each dust sample before calculations of dust concentrations are made.

CALCULATION OF DUST CONCENTRATION

Dust counts usually are expressed as number of particles per cubic centimeter or millions of particles per cubic foot.

Since each sector covers 18° of a circle, the two sectors enclose all particles in 36°, or one-tenth of the total area. Thus, the number of particles per cubic centimeter may be found by multiplying by 10 and dividing by the volume. For a 2.5-cc sample, the total for the two sectors is multiplied by 10 and divided by 2.5 or, more simply, multiplied by 4. Similarly, the count for two sectors of a 5-cc sample is multiplied by 2 to obtain the number of particles per cubic centimeter.

If the results are desired in millions of particles per cubic foot, they may be calculated as follows: The number of particles per cubic centimeter is multiplied by 28,320 (number of cubic centimeters per cubic foot) and divided by 1 million. For a 2.5-cc sample the actual count for two 18° sectors may be multiplied by the factor 0.113. If a 5-cc sample was taken, the count for two sectors should be multiplied by 0.057.

It is difficult for anyone unaccustomed to using a konimeter and microscope to familiarize himself with the entire procedure of sampling, counting, and preparing plates by reading a set of instructions; he should be shown the proper procedure.

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SUMMARY

A circular-type konimeter used by the Bureau of Mines as an adjunct to the impinger is described.

The konimeter is of little value where dust is plainly visible but can be used in preliminary work and for estimating the effectiveness of dust-control methods.

Konimeter samples collected by the Bureau of Mines are counted directly without treatment and with light field illumination.

In preparing the konimeter for use, the disk must be cleaned carefully to remove dust and lint and an adhesive film of a specially prepared jelly applied to retain the dust sampled. The technique for doing this is described.

A 2.5-cc or a 5-cc sample is large enough to determine the dustiness of the air in almost any active plant.

Methods of calculating the number of dust particles per cubic centimeter and per cubic foot of a 2.5-cc or a 5-cc dust sample are given.